Formal Methods
September Lab exam

Exercise 1

You are working for UniTN and you are asked to pack sever virtual machines (VMs) into servers. The complete list of available servers (describing the number of RAM and the storage in GBs they provide) is shown below:

	RAM	storage
srv0	2	100
srv1	4	800
srv2	4	1000
srv3	16	8000
srv4	8	3000
srv5	16	6000
srv6	16	4000
srv7	32	2000
srv8	8	1000
srv9	16	10000
srv10	8	1000

On the other hand, this is the list of the virtual machines you are requested to store:

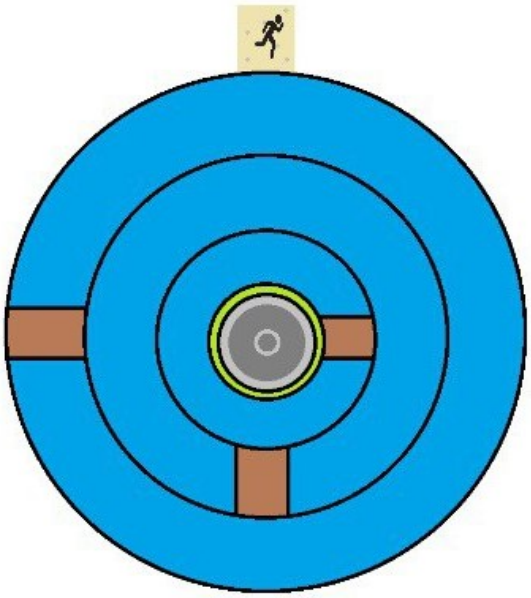
	RAM	storage
VM0	1	100
VM1	16	900
VM2	4	710
VM3	2	800
VM4	4	7000
VM5	8	4000
VM6	2	800
VM7	4	2500
VM8	16	450
VM9	16	3700
VM10	12	1300

Remember that it is **NOT** possible to partially store part of a VM on a server and the remaining part to a different one. The rector of the university is invested in the project and would be pleased to achieve a better efficiency according to the following rule: **We must be sure to retrieve a configuration that minimizes the number of employed servers. The fewer servers you will use, the higher will be your salary**.
Use OptiMathSAT to evaluate the best configuration that could maximize your gain. First try to see if there is at least a way to store the VMs on the servers, independently from the additional rule provided by the rector, and report the result in a comment:

- If no solution is found, write how you assumed it.
- If at least a solution is found, write how you assumed it. Next add some constraints to obtain the configuration that will maximize your salary. Be sure to check if the obtained solution is the only one using that minimal number of servers and provide comments about it.

Exercise 2

To save the princess Pitch from the evil monster Browser you must reach its castle. Unluckily for you, Browser created a complex bridge system to prevent external intruders to access its building.
Around the castle there are 3 concentric rings, each of them containing part of the bridge. When you reach the facility, the pieces of the bridges are not aligned. To align them, you have the opportunity to rotate these rings by 90 degrees using some buttons. Each time you can choose what ring to rotate among the 3 available, choosing between rotating it clockwise or anticlockwise. Moreover, if you rotate a ring, all the rings which are adjacent to it rotate in the opposite direction. For example: if you rotate the innermost ring clockwise by 90 degrees, then the middle ring will rotate anticlockwise by 90 degrees. An image showing the inital state of the bridges is shown below. Can you find a way to find the correct approach to align the bridges?



Use nuXmv to encode the problem and check if there is a way to align the bridges. Use LTL proprerties to check it and extract the minimum number of steps necessary to solve the problem. In addition to that, make sure to satisfy all the following properties:

- If you decide to rotate one of the rings, make sure the reverse move does not happen in the next turn (i.e. rotating the same rings on the opposite direction).
- Use both assignment and constraint style modeling. Not doing so will result in a score penalty.